OCO-2 Status
May 9, 2017

David Crisp for the OCO-2 Science Team

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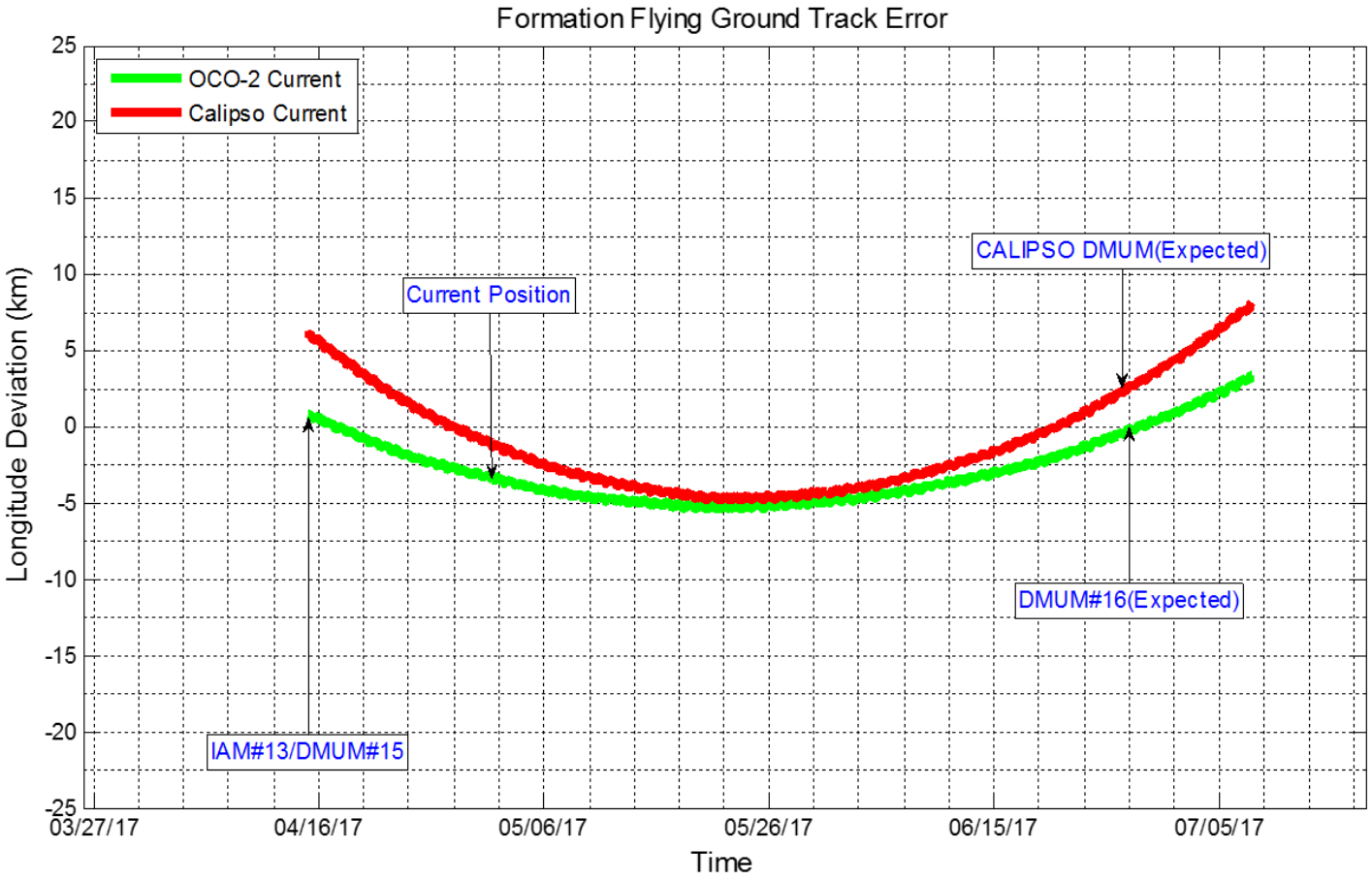
OCO-2 Status

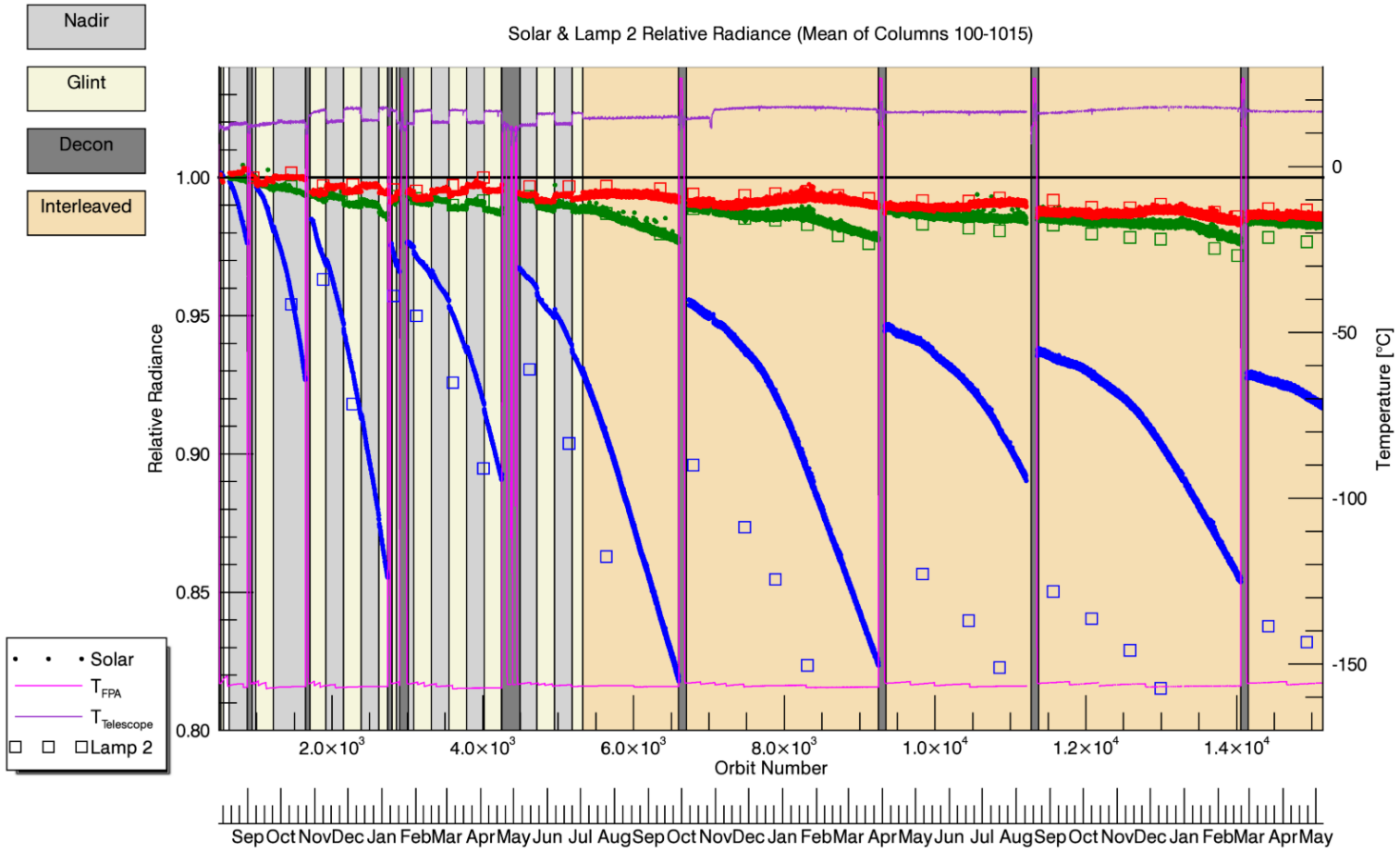
- Observatory Status: Nominal
  - Inclination Adjust Maneuver (IAM) Sequence completed
    - Completed on 13 April
- Instrument Status: Nominal
  - Recovery from February 21 – March 1, 2017 Decon nominal
- V8 Testing and Implementation
  - Testing of Version 8 build development COMPLETE
  - V8 documentation updates needed
- OCO-2 Senior Review Panel Interview tomorrow (5/10)
- Highlights of the A-Train Symposium
- Highlights of the CEOS SIT-32: the CEOS Carbon Activity
- Upcoming meetings and events

OCO-2 and CALIPSO Ground Tracks



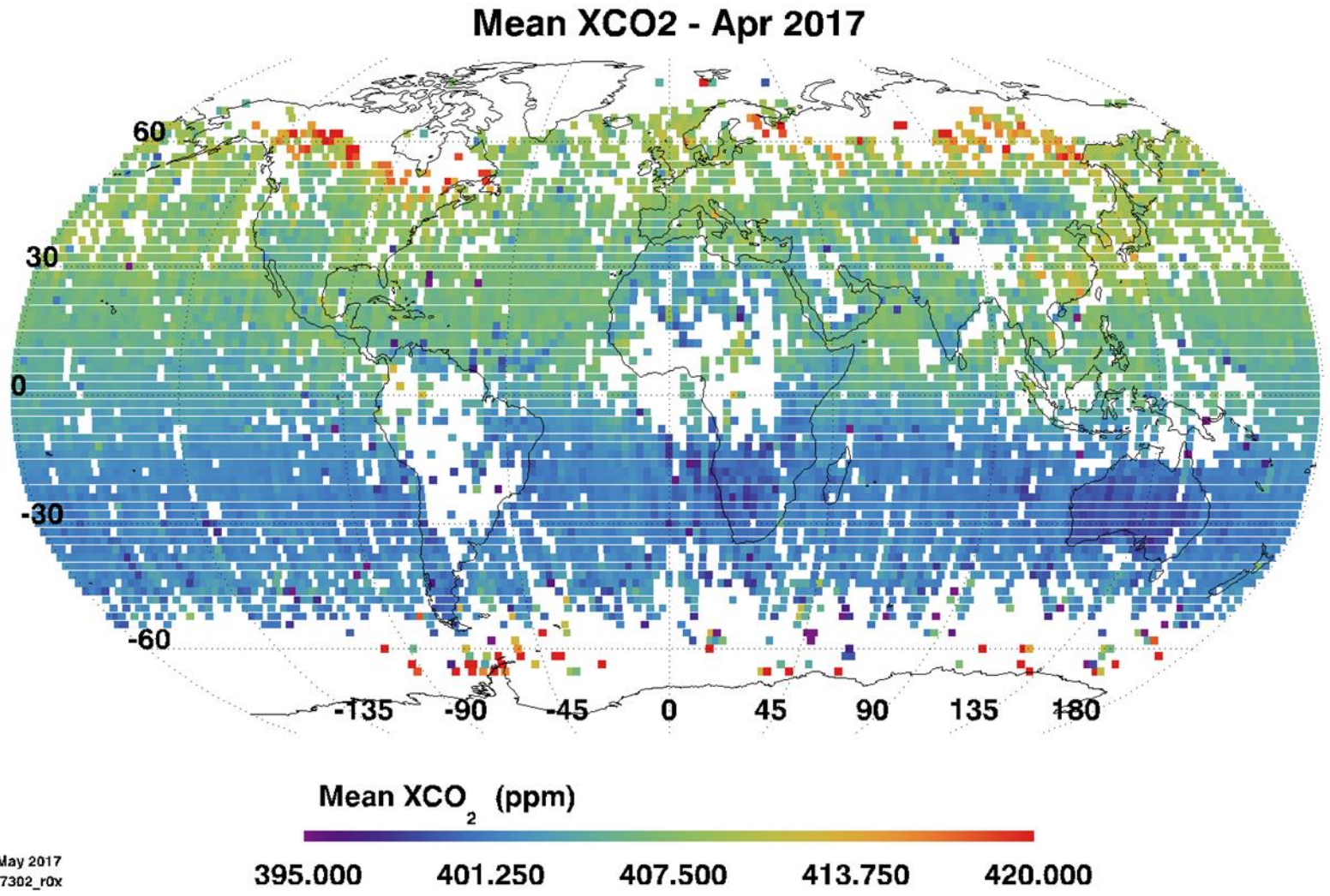
The 2017 Inclination Adjust Maneuver (IAM) series was completed as planned, yielding very good alignment with CALIPSO. MLTAN now 13:35:35
Next Drag Makeup Maneuver around 26 June 2017

OCO-2 Instrument Trending

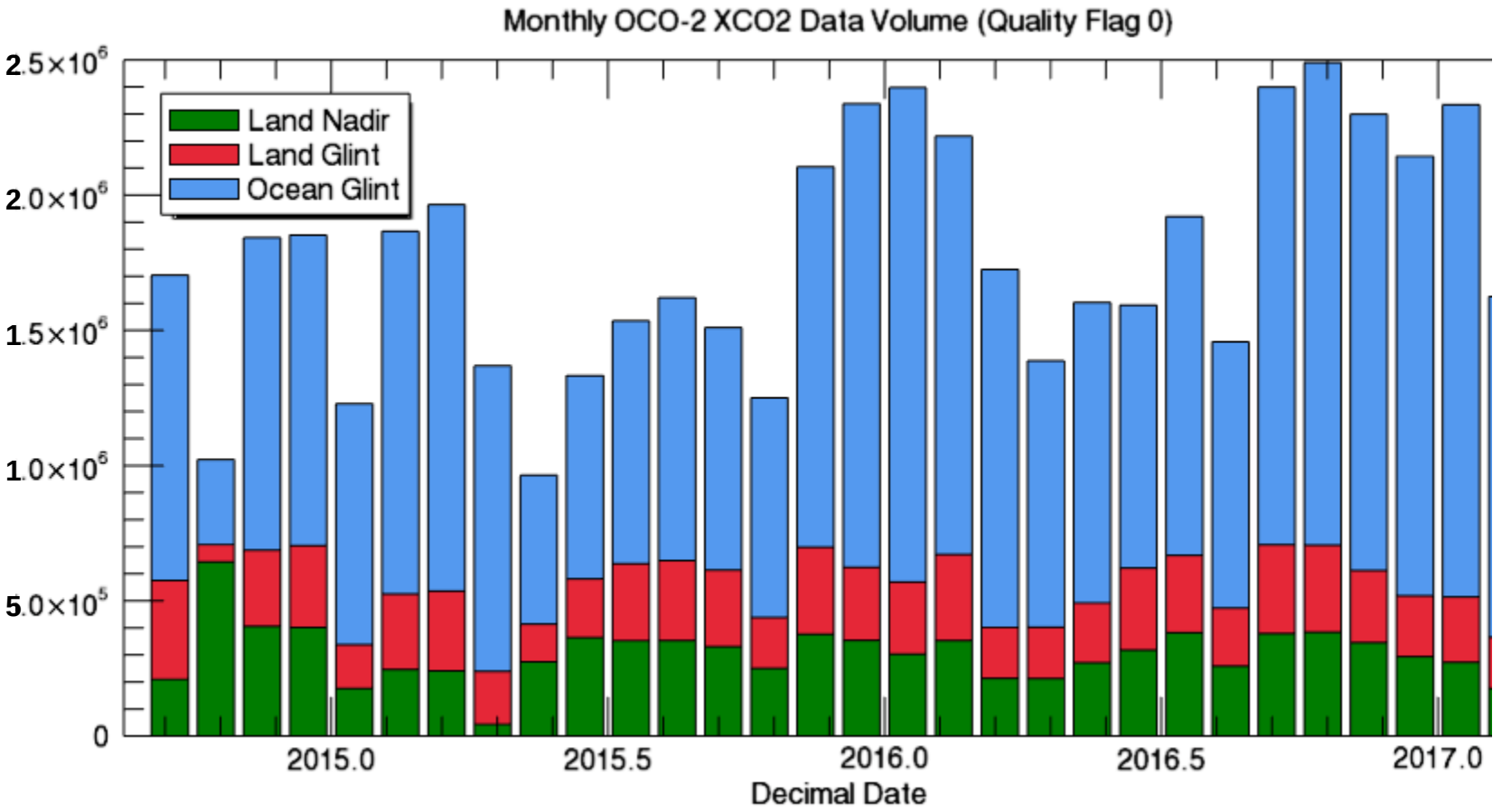


Rate of ice accumulation continues to decrease.

April X_{CO2} Data (forward stream)

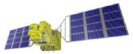


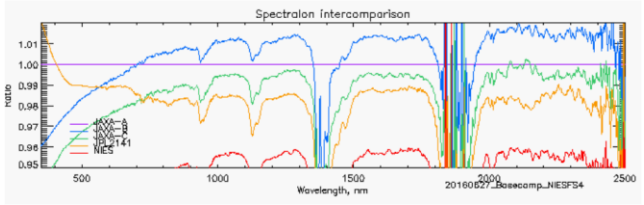
Data Volume
Chris O'Dell



Plots of monthly data volume clearly show the benefits of the "optimal" viewing mode, which acquires ocean glint on orbits predominately over the Atlantic or Pacific Oceans, which was implemented in November 2015.

2017 Railroad Valley Campaign Schedule



	Day of year		OCO-2	orbit	GOSAT				Flight
19-Jun-17	170	Monday	8	none	no path		LAX	Pasadena	
20-Jun-17	171	Tuesday	9	137	36	Golden	Comparison (unpacking)	Pasadena	
21-Jun-17	172	Wednesday	10	none	37		Comparison	Pasadena	
22-Jun-17	173	Thursday	11	none	no path		(Comparison)	Pasadena	
23-Jun-17	174	Friday	12	none	36		Loading	Pasadena	
24-Jun-17	175	Saturday	13	none	37		moving	Tonopah	
25-Jun-17	176	Sunday	14	none	no path	Training	RRV	Ely	
26-Jun-17	177	Monday	15	none	36		RRV	Ely	
27-Jun-17	178	Tuesday	16	none	37		RRV	Ely	
28-Jun-17	179	Wednesday	1	none	no path		RRV	Ely	
29-Jun-17	180	Thursday	2	136	36	Golden	RRV	Ely	AJAX flight
30-Jun-17	181	Friday	3	none	37		RRV	Bishop	
1-Jul-17	182	Saturday	4	none	no path		JPL	Greater LA	
2-Jul-17	183	Sunday	5	none	36		Salton Sea	Greater LA	Proposing

The OCO-2 and GOSAT teams are currently planning the 2017 Railroad Valley Vicarious Calibration Campaign.

Publications Statistics

By 1-May-2017:

- 2014: OCO-2: 7 refereed papers, 1 book chapter
- 2015: OCO-2: 8 refereed papers
- 2015: ACOS: 3 refereed papers, 1 book chapter
- 2016: OCO-2: 18 refereed papers
- 2016: ACOS: 12 refereed papers
- 2017: OCO-2: 12 refereed papers, 10 in review, 1 in press
- 2017: ACOS: 2 refereed papers

Source: Dave, Crisp, OCO-2 Science Team Lead and http://www.isiknowledge.com (key word: OCO-2 OR Orbiting Carbon Observary-2 OR Atmospheric CO2 Observations from Space OR ACOS)

Highlights of the A-Train Symposium

- David, Annmarie Eldering and the OCO-2 Science Team. Synergistic Observations from OCO-2 and Other A-Train Sensors
- Junjie Liu, Kevin Bowman, Dave Schimel, Nick Parazoo, Anthony Bloom, Meemong Lee, Kevin Gurney, Dimitris Menemenlis. American biosphere carbon flux inter-annual variability: from satellite CO_2, phenology, to eddy covariance observations
- Nicholas C. Parazoo. Using A-Train observations to examine resilience and vulnerability of Arctic and boreal ecosystems to climate change
- Aronne Merrelli, Ralf Bennartz, Chris O'Dell. Combining CALIOP and OCO2 for improved XCO2 retrieval
- Ray Nassar, Tomohiro Oda, Debra Wunch, Dylan B.A. Jones. Quantifying Large Anthropogenic CO_2 Sources from OCO-2
- Annmarie Eldering, David Crisp, Michael Gunson. An Update on the OCO-2 Mission Status

Presentations posted at https://atrain2017.org

Ongoing Work for V8: Documentation

Annmarie Eldering

Goals for v8 update

- Harmonize front end/intro material in L1b ATBD/ L2 ATBD/ DUG
- Combine DUG and bias corr/warn level doc
- Plan “Data Quality Statement”
- can we move to online documentation that is easier to update and navigate?

Key Documentation – user's guides

- **User's Guide**: Osterman, G.B., Eldering, A., Avis, C., Chafin, B., O'Dell, C.W., Fisher, B., Mandrake, L., Wunch, D., Granat, R., Crisp, D., Orbiting Carbon Observatory–2 (OCO-2) Data Product User's Guide, Operational L1 and L2 Data Versions 7 and 7R, http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2-v7/OCO2_DUG.V7.pdf, 2016
  - Brief overview of OCO-2 mission; description of operational Level 1 and Level 2 data files; naming conventions; key data fields; recommendations for quality screening; tools to view and search the data products.
- **XCO2 Lite files and Bias Correction**: Mandrake, L., O'Dell, C., Wunch, D., Wennberg, P.O., Fisher, B., Osterman, G.B., Eldering, A.: Lite Files, Warn Levels, and Bias Correction Determination, NASA Jet Propulsion Laboratory, California Institute of Technology, Version 1, http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2-v7/OCO2_XCO2_Lite_Files_and_Bias_Correction_0915_sm.pdf, (last access July 2016), 2015
  - This document provides the details of the contents of the most recent releases of the OCO-2 lite files, the bias correction, and the recommended warn levels.
- **SIF Lite files**: Frankenberg, C; Solar Induced Chlorophyll Fluorescence OCO-2 lite files (B7000) user guide, Technical Report, NASA Jet Propulsion Laboratory, California Institute of Technology, http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2-v7/OCO2_SIF_B7000_Product_Description_090215.pdf, (last access July 2016), 2015
  - This document provides details about the Solar Induced Chlorophyll Fluorescence (SIF) Lite files and the SIF correction procedure.

Key Documentation: L1b ATBDs and ASDs

- **L1b ATBD**: Eldering, A, Pollock, R., Lee, R., Rosenberg, R., Oyafuso, F., Crisp, D., Granat, R.: Orbiting Carbon Observatory (OCO) – 2 Level 1B Theoretical Basis Document, D-55206, NASA Jet Propulsion Laboratory, California Institute of Technology, Version 1.2, Rev 1, http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2-v7/OCO2_L1B_ATBD.V7.pdf, (last access June 2016), 2015
  - This Algorithm Theoretical Basis Document (ATBD) describes the Level 1B data and the process used to transform the inherent instrument measurements (L1A data) into radiometrically calibrated spectra (L1B data). A brief instrument description is included.
- **L1b ASD**: Avis, C OCO (Orbiting Carbon Observatory) Project OCO-2 Algorithm Specification Document - Level 1B Process, D-81523, NASA Jet Propulsion Laboratory, California Institute of Technolog http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2-v6/Level_1B_ASD.V6.PDF, (last access Oct. 2016), 2015
  - L1B Algorithm Specification Document (ASD) is a companion document to the L1B ATBD.

Key Documentation: L2 ATBD

- **L2 ATBD**: Crisp et al., Orbiting Carbon Observatory (OCO) – 2 Level 2 Full Physics Algorithm Theoretical Basis Document, D-55207, NASA Jet Propulsion Laboratory, California Institute of Technology, Version 2.0, Rev 2, http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2-v5/OCO-2_ATBD_140530_with_ASD.pdf (last access June, 2016), 2014
  - The algorithm theoretical basis used to retrieve the column-averaged CO_2 dry air mole fraction XCO2 and other quantities included in the Level 2 (L2) Product from the spectra collected by the Orbiting Carbon Observatory-2 (OCO-2). It identifies sources of input data; describes the physical theory and mathematical background underlying the use of this information in the retrievals; includes implementation details; and summarizes the assumptions and limitations of the adopted approach. The ASD is integrated in this document.

Key Documentation: prescreener ATBDs

- **ABO2 ATBD:** O'Dell, C.W. and Taylor, T.E., OCO-2 Algorithm Theoretical Basis Document Oxygen-A Band Cloud Screening Algorithm (ABO2), JPL document number: D-81520, , http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2/oco2_abo2_atbd_prelaunch_4.pdf, (last access Oct 2016), 2014
  - Details the so-called Oxygen-A Band cloud screening algorithm, which will be one of two primary cloud screening tools implemented in the operational OCO-2 processing pipeline.
- **IMAP-DOAS ATBD:** Frankenberg, C., OCO-2 Algorithm Theoretical Basis Document IMAP-DOAS preprocessor, JPL Document number: D-81519, http://disc.sci.gsfc.nasa.gov/OCO-2/documentation/oco-2-v5/IMAP_OCO2_ATBD_prelaunch.pdf, (last access Oct 2016), 2014
  - The algorithm theoretical basis for the IMAP-DOAS preprocessor, which is used for both screening of the official XCO2 product as well as for the retrieval of Solar-Induced Fluorescence from the 0.76 µm O_2 A-band. The IMAP-DOAS preprocessor, just as the ABO2 cloud screen, is implemented in the operational OCO-2 processing pipeline.

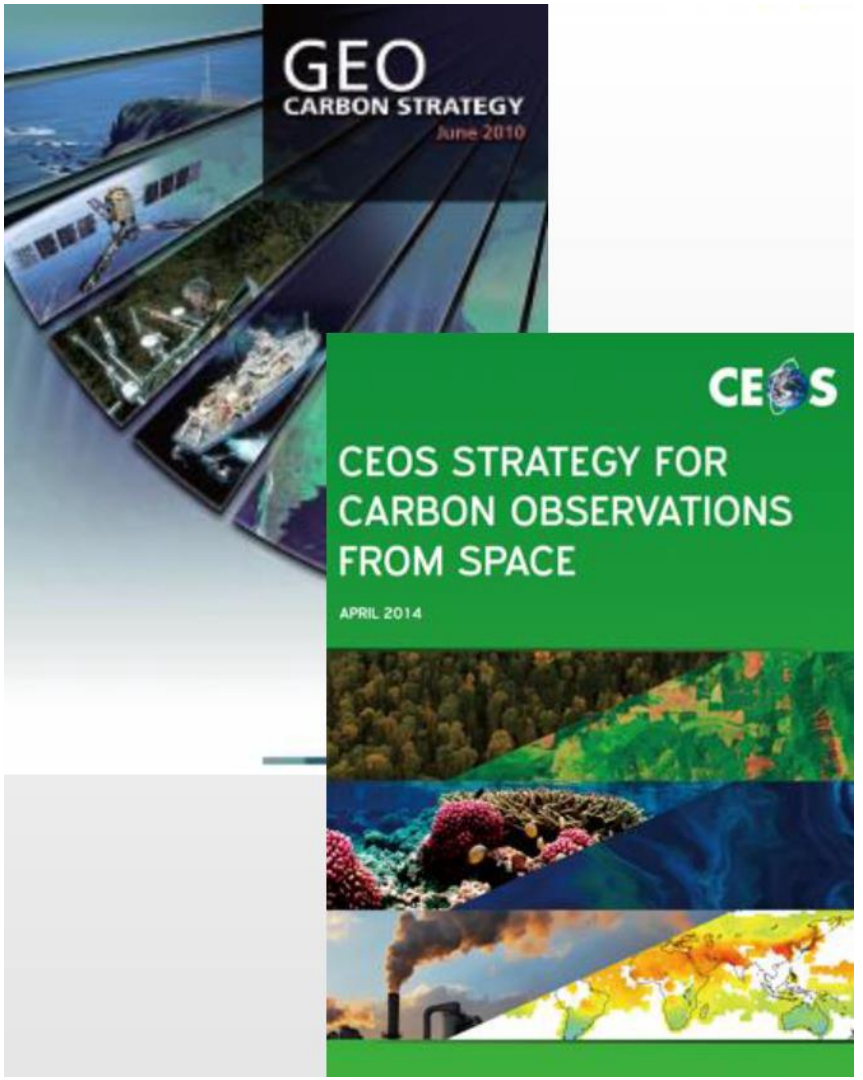
Document Leads (who to talk to!!)

- Lars Chapsky and Rob Rosenberg – write ups on ZLO and gain degradation coefficients (start with memo – then we can integrate in the L1b ATBD and DUG. Will need to append to A-band tiger team report
- Rob and Chris – user's guide explanation of (a) use of dispersion equation including fitted terms, (b) use of SAA flagging (c) use of bad sample masks, (d) and use of SNR coefficients
- Chris – Write this for paper and then integrate in L2 ATBD – stratospheric aerosols
- Vijay – same for BRDF
- Brendan – solar model, tropopause, cirrus height
- Greg – proposal for data quality statement development and updates

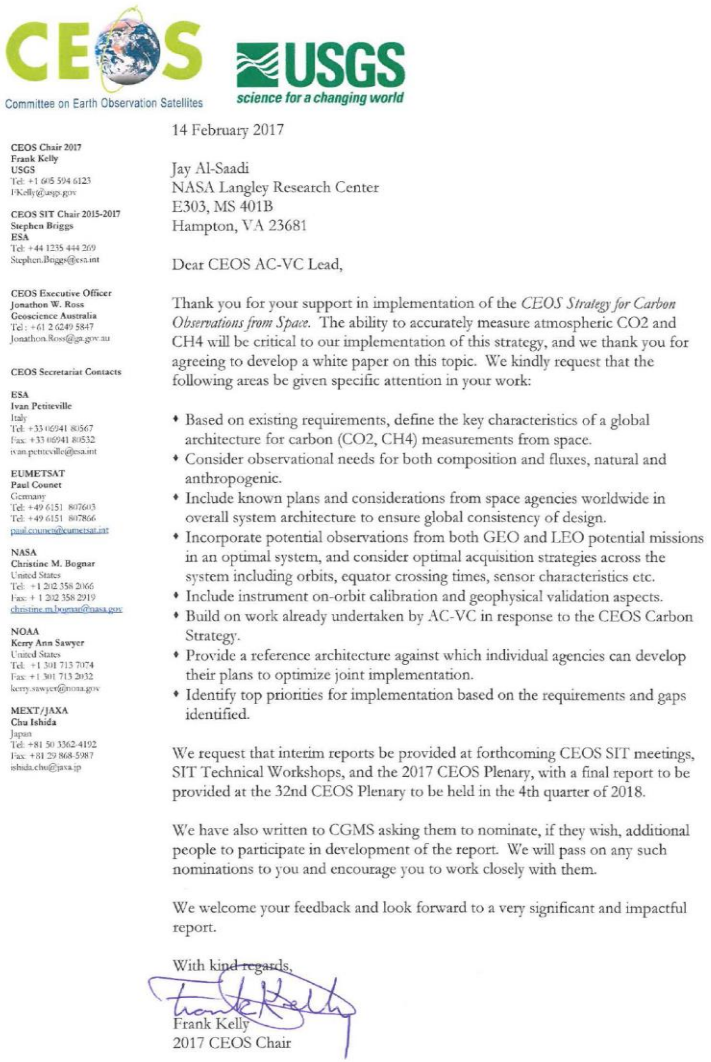
CEOS AC-VC GHG White Paper

CEOS Atmospheric Carbon Activity History and Background

- GEO Carbon Report developed in June 2010 by team led by Ciais et al. (GCP).
- *CEOS Strategy for Carbon Observations from Space*–written in response to above, completed in March 2014 –*Wickland et al.*
- **Deliveries:**
  - Merged CARB AI 16+18: AC-VC to support the organization of yearly IWGGMS (FMI (Helsinki, Finland) on 6-8 June 2017
  - Merged CARB AI 17+19+23: AC-VC will prepare a white paper within 2 years
  - CARB AI 20: AC-VC will write a Technical Note within 2 years



14 February 2017 Letter from the CEOS SIT



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14 February 2017

Jay Al-Saadi
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Dear CEOS AC-VC Lead,

Thank you for your support in implementation of the *CEOS Strategy for Carbon Observations from Space*. The ability to accurately measure atmospheric CO2 and CH4 will be critical to our implementation of this strategy, and we thank you for agreeing to develop a white paper on this topic. We kindly request that the following areas be given specific attention in your work:

- Based on existing requirements, define the key characteristics of a global architecture for carbon (CO2, CH4) measurements from space.
- Consider observational needs for both composition and fluxes, natural and anthropogenic.
- Include known plans and considerations from space agencies worldwide in overall system architecture to ensure global consistency of design.
- Incorporate potential observations from both GEO and LEO potential missions in an optimal system, and consider optimal acquisition strategies across the system including orbits, equator crossing times, sensor characteristics etc.
- Include instrument on-orbit calibration and geophysical validation aspects.
- Build on work already undertaken by AC-VC in response to the CEOS Carbon Strategy.
- Provide a reference architecture against which individual agencies can develop their plans to optimize joint implementation.
- Identify top priorities for implementation based on the requirements and gaps identified.

We request that interim reports be provided at forthcoming CEOS SIT meetings, SIT Technical Workshops, and the 2017 CEOS Plenary, with a final report to be provided at the 32nd CEOS Plenary to be held in the 4th quarter of 2018.

We have also written to CGMS asking them to nominate, if they wish, additional people to participate in development of the report. We will pass on any such nominations to you and encourage you to work closely with them.

We welcome your feedback and look forward to a very significant and impactful report.

With kind regards,

Frank Kelly
2017 CEOS Chair

In February 2017, the AC-VC received a formal request from the CEOS Chair, Frank Kelly

- **Included specific guidance on the content of the GHG White Paper**
- **Requests interim reports be provided at forthcoming CEOS SIT meetings, SIT Technical Workshops, and the 2017 CEOS Plenary**
- **Requests a final report to be provided at the 32nd CEOS Plenary to be held in the 4th quarter of 2018**
- **Invited CGMS asking them to nominate, if they wish, additional people to participate in development of the report**

Mandate for Satellite GHG White Paper content, undertaken by CEOS AC-VC

- Based on existing requirements, define the key characteristics of a global architecture for carbon (CO2, CH4) measurements from space.
- Consider observational needs for both composition and fluxes, natural and anthropogenic
- Include known plans and considerations from space agencies worldwide in overall system architecture to ensure global consistency of design
- Incorporate potential observations from both GEO and LEO potential missions in an optimal system, and consider optimal acquisition strategies across the system including orbits, equator crossing times, sensor characteristics etc.
- Include instrument on-orbit calibration and geophysical validation aspects
- Build on work already undertaken by AC-VC in response to the CEOS Carbon Strategy
- Provide a reference architecture against which individual agencies can develop their plans to optimise joint implementation.
- Report at Plenary 2017, with interim report SIT (April 2017)

Scope of the AC-VC GHG White Paper

Define the key characteristics of a global architecture for carbon (CO_2, CH_4) measurements from space

- Need for space-based measurements of CO_2 and CH_4
- Existing space-based GHG Satellites and near term plans
- Integrating diverse Missions into a Virtual Constellation
- Lessons Learned from GOSAT and OCO-2
- Deriving GHG Constellation Requirements
- Candidate Constellation Architectures
- Constraining inventories with space based GHG measurements – retrieving GHG fluxes
- Conclusions

The CEOS Perspective

The GHG White Paper should

- Facilitate coordination of ongoing efforts by member agencies
- Focus on calibration and validation of space-based data and products
- Emphasize value of an open data policy and common product formats
- Foster use of space-based greenhouse gas (GHG) observations
- Consolidate data requirements for next-generation GHG satellites

Milestones for GHG White Paper Development

- 25-28 April: CEOS SIT, Paris, France
  - Present a report on the GHG White Paper progress and plans
- 6-8 June: IWGGMS-13, Helsinki, Finland
  - AC-VC participation in Organizing Committee and opportunities to enlist participation in GHG White Paper among space-based GHG measurement and modeling communities
- 11-16 June: GHG report to the CGMS-45, Jeju Korea
  - Opportunity to solicit input on GHG White Paper from operational agencies
- 28-30 June: CEOS AC-VC, CNES HQ, Paris, France
  - Breakout session to harmonize mission requirements (GEO, GCOS, CEOS)
  - Finalize GHG White Paper outline and writing assignments
- 21-25 August, ICDC10, Interlaken, Switzerland
  - First drafts of all chapters due
- 11-14 September, 2017 SIT Technical Workshop, Frascati, Italy
  - Present a report on the GHG White Paper scope and contents

Upcoming activities

Upcoming Activities

- 20-25 May: JpGU, Chiba, Japan
  - Talks + Hyperwall
- 23-24 May: NOAA ESRL GMD Annual Meeting, Boulder CO
  - Chris O'Dell will represent OCO-2
- 6-8 June: IWGGMS, Helsinki
  - Program: http://iwggms13.fmi.fi/program/Daily_program.pdf
- 11-16 June: CGMS-45 (Carbon Session on 16 June)
- 28-30 June: CEOS AC-VC, CNES HQ, Paris
- 6-11 August, AOGS, Singapore
- 21-25 August, ICDC10, Interlaken, Switzerland
- 11-14 September, 2017 SIT Technical Workshop, Frascati, Italy